PATENT SPECIFICATION

DRAWINGS ATTACHED

824,813

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COMPLETE SPECIFICATION

Well Completion Apparatus

I, GEORGE AARON BUTLER, of 300 Gulf Building, Houston 2, State of Texas, United States of America, a citizen of the United States of America, do hereby declare the invention for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention pertains to apparatus for supporting vertical conduits, and more particularly to apparatus used in connection with wells for supporting a casing or other pipe in the well, the point of support being near, and usually above, the level of the ground.

It is a principal object of the present invention to provide apparatus for suspending or hanging vertical conduits, the said apparatus having short vertical length.

Another object of the invention is to provide such pipe hanging apparatus which is safe and reliable.

Another object of the invention is to provide such apparatus which, in addition to adequately supporting the pipe, also provides an effective fluid seal around the pipe.

Another object of the invention is to provide apparatus for supporting a pipe in a well, especially a well casing.

A further object of the invention is to provide casing supporting means including pack-off means around the casing to seal the annulus, wherein the axial compression of the pack-off means is controlled.

Other objects and advantages of the invention will appear from the following description of a preferred embodiment thereof, reference being made to the accompanying drawings, of which:

Figure 1 is a vertical half-section showing the preferred embodiment of the casing hanger and casing head, a portion of a surmounting well head being shown;

Figure 2 is an enlarged partial vertical section of the casing hanger and casing head of Figure 1, showing the hanger in the unset position;

Figure 3 is the same as Figure 2, showing the hanger in the set position; and,

Figure 4 is an enlarged partial horizontal section, taken at line 4—4 of Figure 3.

Referring now in detail to the drawings, a casing head 10 of more or less conventional design has a vertical axial opening 11 of generally cylindrical form around the sides of which are formed three axially spaced downwardly converging annular conical surfaces 12—14, all of which are conical but of differing tapers or slopes. The upper surface 12 is disposed at the lower end of the enlarged upper end 15 of opening 11, and is not usually used as a seat. The center surface 13 is steeply inclined downwardly and of greater axial length than surfaces 12 and 14, and serves as the supporting seat for the pipe or casing 17 and the hanger elements to be described. The lower surface 14 is provided to reduce the diameter of opening 11 at the upper end of the lower socket formation 18 of the casing head.

Casing head 10 has a circular upper flange 20 for bolted connection of the casing head to surmounting equipment. A circular groove 21 around opening 11 in the upper flange face receives a steel ring gasket 22 for providing a fluid-tight seal at the connection. A side or lateral thread passage 25 permits communication between the interior of casing head 10 around casing 17 and within surface casing 30, and the exterior of the completion, the outer wall of passage 25 being thickened as at 31.

The lower threaded socket 18 of casing head 10 threadingly receives the upper exteriorly threaded end 34 of casing 30, casing head 10 and the surmounting equipment being supported thereby above the well. Casing 17 is concentrically disposed within surface casing 30, and runs therethrough into the well. The upper end of casing 17 extends above casing head 10 to be sealed into the surmounting equipment, which is generally referred to by reference numeral 37.

A circular hanger 40 has a more or less vertical outer wall 41 and a horizontal flange 42

[Price 3s. 6d.]

projecting inwardly from the upper end wall 41. Wall 41 provides outwardly and downwardly facing conical seat surface 43 of downwardly converging taper of the same slope as seat surface 13, vertical outwardly facing surface 44 below surface 43, and lower outwardly and downwardly facing conical surface 45 of a downwardly converging taper of about the same slope as surface 14 of the casing head. Inwardly, wall 41 presents a uniform conically tapered downwardly converging surface or slip seat 47 of about the same slope as surfaces 13 and 43.

Horizontal flange 42 of hanger 40 is tapped inwardly of wall 41 to threadingly receive a plurality of circularly arranged vertical screws 48 for holding down and/or compressing sealing or pack-off elements 50, 51, 52. Element 50 is a steel packing support ring flushly seated upon flange 42 when the hanger is unset as in Figure 2 and spaced above flange 42 when the hanger is set as in Figure 3. Ring 50 has outer downwardly converging conical surface 55 which seats upon an upper portion of seat 13 whereby the ring is axially supported. A small annular clearance 56 is provided between the ring 50 and casing 17. Element 51 is a packing ring of elastomeric resilient material and has upper flange formations 57, 58 and lower flange formations 59, 60 which fit into corresponding outer and inner recesses of elements 50, 52. Ring 51, when axially compressed between elements 50, 52, seals the annular space between casing head 10 and casing 17 so that no fluids can flow therepast. Element 52 is a steel compression ring covering the upper surface of ring 51, and provided with a plurality of screwhead recesses 63 for the screws 48, which extend through elements 50—52 to threadingly engage the tapped openings in flange 42. When the hanger is set, as shown in Figure 3, the screws 48 draw compression ring 52 downwardly to axially compress ring 51 to form the described seal.

A plurality of identical slip members 70 are movably disposed against the conical surface 47 of hanger 40. Each slip forms a segment of a more or less continuous ring of the slips occupying part of the annular space between casing 17 and surface 47, and beneath flange 42. Each of the slips has an upper and outer horizontal groove 71 for receiving a steel snap ring 72 which extends around the slips to hold them assembled. Each slip also has a threaded hole perpendicularly of its outer surface for threadingly receiving a screw 73 extending inwardly through hanger 40.

The outer and bottom surfaces 44, 45 of hanger 40 have a plurality of equally spaced apart recesses 75 therearound, the narrow webs 76 being disposed between adjacent recesses. Recesses 75 provide clearance for flow of fluids between surface casing 30 and ports 25, and extend downwardly from the upper edges of the ports 25. It is not necessary that the ports 25 register with a recess 75, since the webs 76 are narrower than the ports and cannot block the ports.

Each recess 75 has a smaller recessed portion 78 providing an abutting surface for the head of a screw 73. A vertical slot 79 receives the shank of the screw which is threaded into the threaded slip hole. Screws 73 are used for holding the slips retracted outwardly during assembly of the hanger, and are loosened after the hanger is in place around casing 17.

Each slip member 70 has a horizontally grooved or threaded inner surface 81 for engaging the wall of casing 17, and a conical horizontally grooved or threaded outer surface 82 corresponding in slope with hanger surface 57 with which it engages. The thread formations as surface 81 are preferably upwardly pointing sharp threads, while thread formations at surface 82 are preferably downwardly pointing threads having a substantial smooth contact area with the hanger surface 47. The slips are described and claimed in British Patent No. 765,635, dated March 14, 1955, and entitled " A pipe anchoring for well tools ". As disclosed in that application, in setting the slips, the sharp inner threads first bite into the casing and take the weight of the casing. The larger-surfaced outer threads slide downwardly in their bowl (in the present case, surface 47) until the force radially across the slips reaches a predetermined maximum value, whereupon the outer threads bite into their bowl surface to stop further downward motion and further increase in said radial force. The said predetermined radial force is less than the force sufficient to radially collapse or " bottleneck " the supported casing, so that the casing is protected against collapse.

The surmounting equipment referred to by reference numeral 37 comprises a tubing head 85 into which the upper end of casing 17 is sealed. Tubing head 85 has a lower flange 86 which is bolted to flange 20 by a plurality of the bolts 87, the steel ring 22 providing a fluid-tight seal between the two flanges. Tubing head axial opening 88 of varying circular cross section is enlarged at its lower end at 89 and further enlarged at 90. A bevel-edged circular steel plate 91 may be urged upwardly by screwing in on a plurality of lockscrews 92 which are disposed radially through and spaced apart around flange 86. The upper reduced part of plate 91 serves as a gland for compressing elastomeric packing ring 93 which surrounds casing 17 in the annular space between casing 17 and the wall of opening 89. A support ring 94 bears against the shoulder at the upper end of opening 89 and extends over the end of casing 17, and the reduced lower end thereof supports packing ring 93 when the packing ring is axially compressed. When plate 91 is urged upwardly by lockscrews 92, the upper part thereof compresses packing ring 93 against ring 94 to form a fluid-tight seal

around the upper end of casing 17 in the annular space. Tubing head 85 has side outlet 96 to provide access to opening 88 thereof.

The hanger 40 and packing elements 50—52 are preferably of the warp around type so that they can be opened up and placed around the casing 17. Hanger 40 and elements 50—52 are broken at one side and are hinged at the diagonally opposite side to permit opening. Wrap around hanger equipment is well known in the art, and no detailed description thereof is here required.

When the hanger equipment is disposed around casing 17 and dropped into the casing head opening 11, seat 55 and ring 50 seats first on an upper portion of seat 13 and ring 50 supports rings 51, 52 and also supports hanger 40 and slips 70 by screws 48. Flange 42 is supported flushly against the lower side of ring 50, and conical seat 43 of hanger 40 is supported above a lower portion of seat 13. Surface 45 is spaced a greater distance above surface 14. This unset position of the hanger is shown in Figure 2.

When the weight of casing 17 is put onto the hanger to set the hanger, the threads at slip surfaces 81 engage and bite uniformly into the outer wall of casing 17, whereby the slips are dragged downwardly on surface 47. When the radial force at the slips is great enough, the threads at surfaces 82 of the slips bite into surface 47 to set the slips. Meanwhile, the downward thrust of casing 17 is transferred through the slips to hanger 40, which is pulled axially downwardly until conical seat 43 seats on a lower portion of conical seat 13. Flange 42 is now spaced below ring 50, and ring 52 has been pulled downwardly by screws 48 to compress packing ring 51 against ring 50 which remains in its previous position. Surface 45 is still spaced above surface 14, so that support for all of the hanger assembly and casing 17 is provided at conical seat 13 of the casing head. This set condition of the equipment is shown in Figure 3 and also in Figure 1.

It should be noted that outer vertical surface 44 of hanger 40 remains against the wall of opening 11 at all times because of the wedging action of the slips.

The apparatus according to the invention may by summary be said to include three functional parts, which are: an annular sealing or pack-off means (rings 50, 51, 52) which seats on the upper portion of the casing head seat 13; an annular pipe hanger means 40 which is held above the lower portion of the casing head seat 13 by its connection to the pack-off means when not under load of a pipe (casing 17) in the well, and which when loaded by a pipe in the well is seated on said lower casing head seat portion and at the same time compresses the pack-off means through said connection; and, the connection between the pack-off means and the pipe hanger means provided by screws 48.

The novel arrangement of these three functional parts of the apparatus permits seating of both the pack-off means and the hanger on a single seat in the casing head opening. The advantages of the arrangement are several. One advantage is that the seal-forming compression of the pack-off means may be adjusted before the apparatus is dropped into the casing head bowl. This is done by simply adjusting the vertical distance that the outer conical surface of the unloaded hanger means is above that lower part of the conical seat of the hanger body when the hanger is not loaded. When the hanger means is subsequently loaded the said distance will be equal to the axial compression of the pack-off means.

Another advantage is that the functional elements may be dropped as a unit into the casing head bowl, provided by seat 13, there being no necessity for bolting the elements together after they are in the bowl, and there being no necessity for adjusting the connection therebetween after the connected elements are dropped into the casing head bowl.

WHAT I CLAIM IS:—

1. A well completion apparatus having a casing head with a vertical opening extending therethrough above a well, a tubing head surmounting said casing head and having sealed bolted flange connection therewith and having a continuation of said opening therethrough, including an upwardly-facing conical seat of steep taper around said opening in the casing head, pipe hanger means seatable on a lower portion of said seat, annulus sealing means seated on an upper portion of said seat, said hanger means being connected to said sealing means, said sealing means supporting said hanger above its said seat portion through a connection means when said hanger means is not supporting the weight of a pipe in the well, said hanger means when supporting a pipe in the well being seated on its said seat portion by the weight of said pipe and thus moved downwardly, said downward movement of said hanger means acting through said connecting means to cause said sealing means to form a fluid-tight seal between the said pipe and said tubing head above said hanger means.

2. A well completion apparatus as set forth in Claim 1, including first means for engaging a well pipe, said sealing means comprising vertically compressible second means above said first means, said connecting means vertically compressing said second means when said first means is supporting the well pipe and automatically sealing off the annular space surrounding said well pipe.

3. A well completion apparatus as set forth in Claim 2, wherein said first means includes a plurality of wedge shaped slip means inwardly of said hanger for engaging and supporting said well pipe, said slip means having inward means for supportably engaging said well pipe and outward means for engaging said hanger.

4. A well completion apparatus as set forth in Claim 2, wherein said second means include a lower ring member in the annular space between the pipe and said upward facing conical seat and supported on said upper seat portion, an intermediate packing ring of elastomeric material above said lower ring, and an upper ring member above said packing ring, said hanger having an upper flange means disposed inwardly from the slip-engaging lower portion thereof, said connecting means comprising a plurality of screws spaced around and threadingly engaging said flange means and extending through said second means to engage upper surfaces of said upper ring with their heads, whereby when said hanger moves downwardly when set to support the well pipe, the said plurality of screws draw said upper ring downwardly to axially compress the packing ring and form a fluid-tight seal around the well pipe, and whereby the extent of axial compression of said packing ring may be adjusted by adjusting said threaded engagements of said screws in said flange means.

5. A well completion apparatus as set forth in Claim 4, wherein said hanger comprises an upwardly-facing conical slip seat at its lower end and having a downwardly-facing conical seat around its outer surfaces for seating upon a lower portion of said conical seat in said casing head, and said lower ring having a peripheral downwardly facing conical seat for seating upon a portion of said conical seat in said casing head above said lower portion thereof, the vertical distance between said outer conical seat of said hanger body and said lower portion of said conical seat in said casing head being greater than zero when said slip members are not supporting said well pipe, said vertical distance being equal to zero when said slip members are supporting said well pipe, said lower ring seat being seated upon its portion of said conical seat in said casing head whether or not said slip members are supporting said well pipe.

6. A well completion apparatus as set forth in Claim 1, including means in the lower end of the opening in said tubing head for furnishing a fluid tight seal around the upper end of said well pipe extending thereinto, whereby a continuous sealed fluid passage is provided comprising said well pipe and said opening continuation in said tubing head.

7. A well completion apparatus substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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824,813 COMPLETE SPECIFICATION
3 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

FIG. 1.

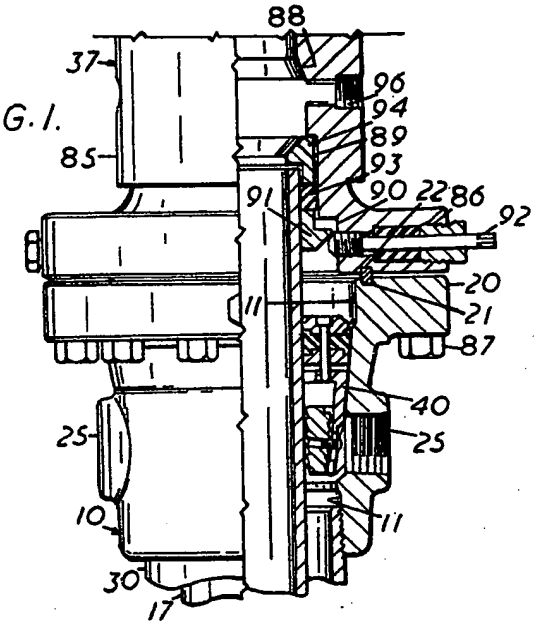


FIG. 4.

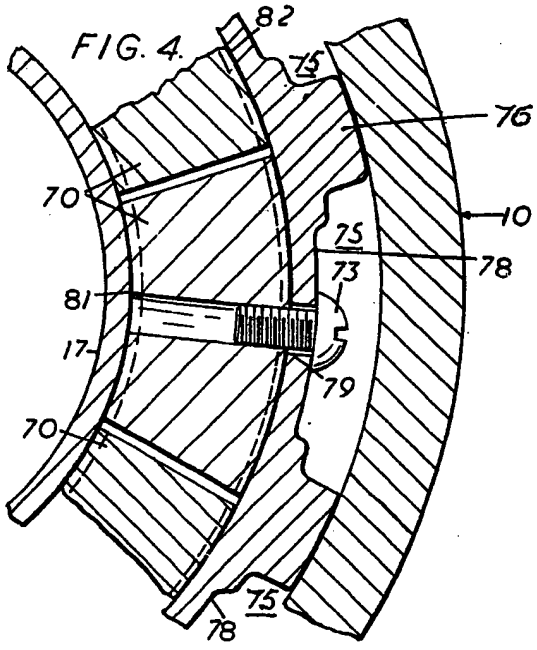
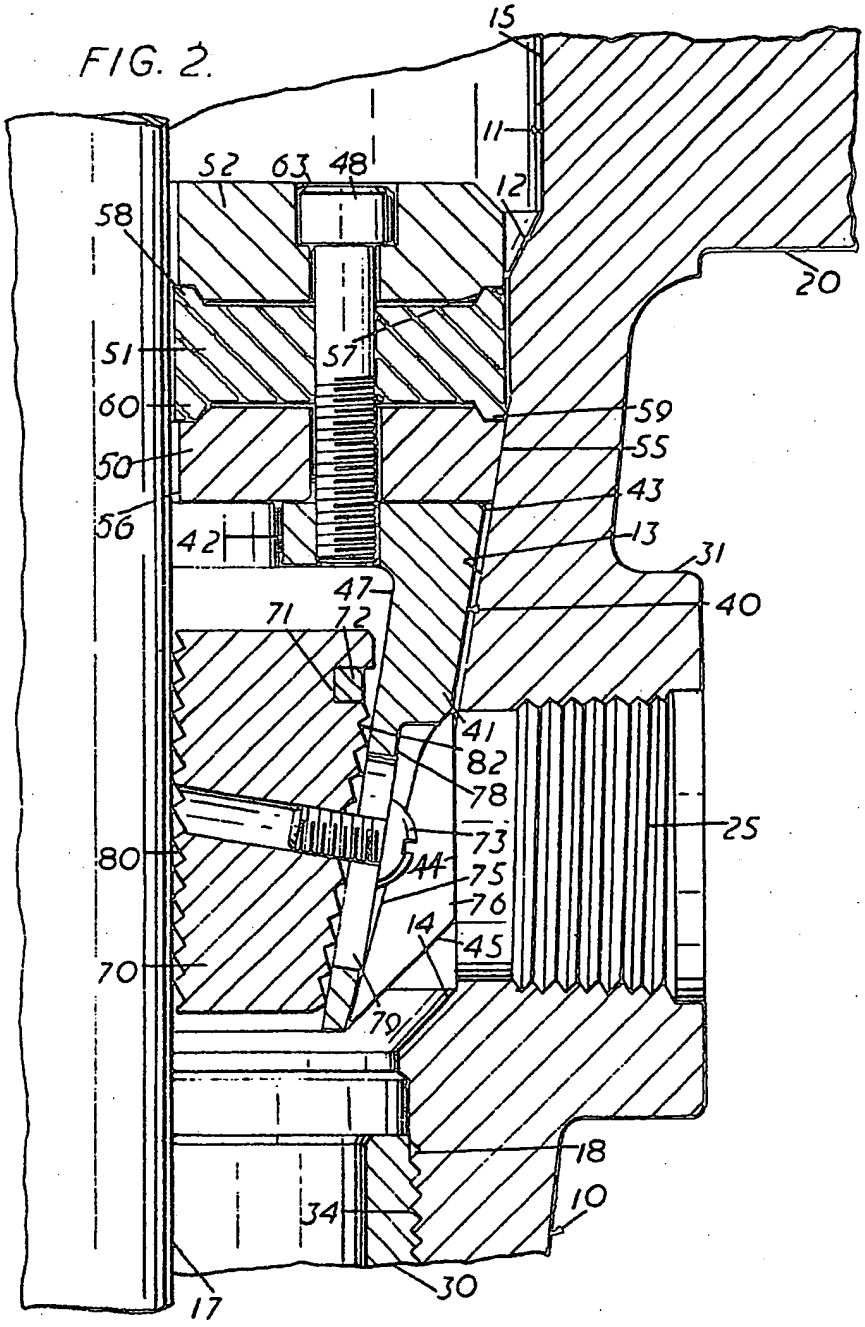


FIG. 2.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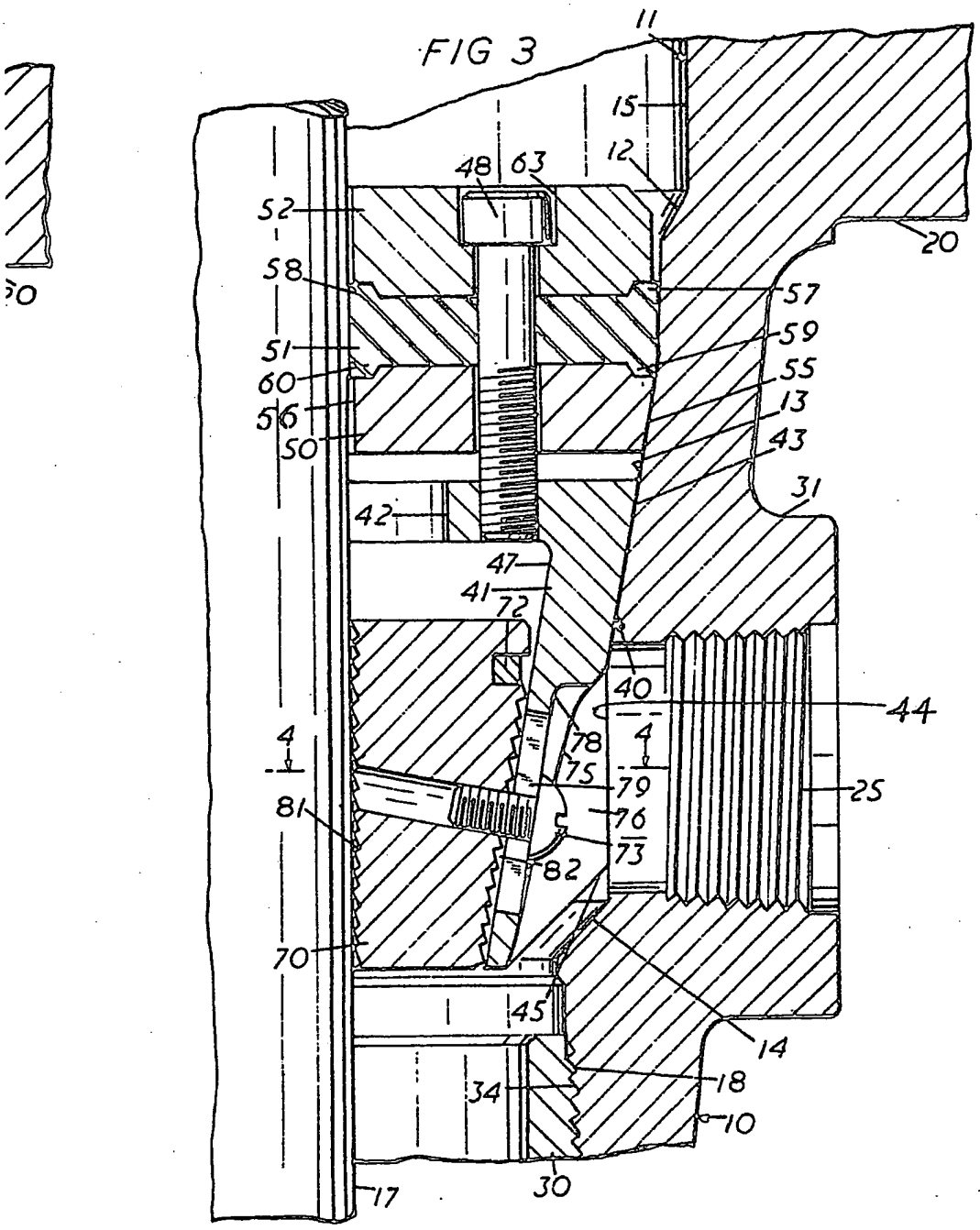
824,813 COMPLETE SPECIFICATION
3 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 2 & 3

FIG 3



824,813 COMPLETE SPECIFICATION

3 SHEETS This drawing is a reproduction of the Original on a reduced scale.

SHEETS 2 & 3

FIG. 2.

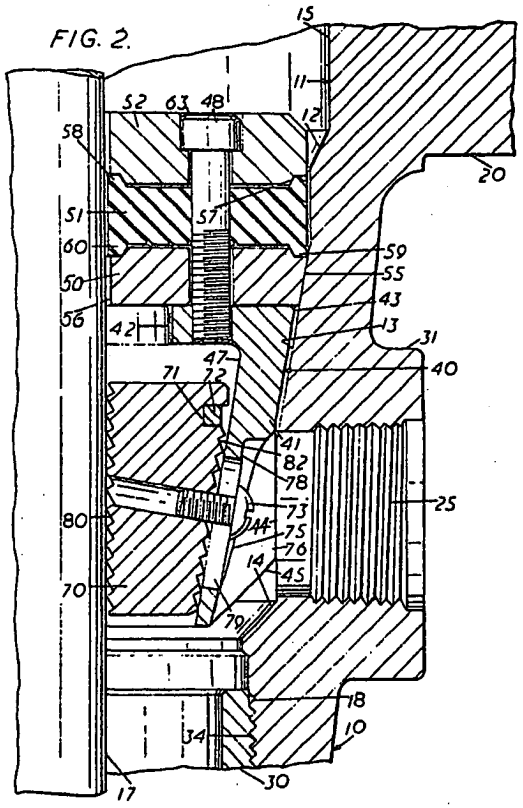


FIG 3